to withstand the force of extremely strong winds with tolerable difficulties. Besides the velocity is much less near a rough rocky surface than in the free air where the anemometer is exposed.

Only slight damage occurred, chiefly to the exposed instruments. A structure supporting a special wind vane, situated at the end of the trestle, partly collapsed and badly smashed a snow gauge. Another wind vane on the trestle was slightly damaged, and the wind vane on the summit tank developed trouble. The observatory building shook considerably under the severe impact, but obviously the heavy covering of rough frost on the exposed east side, and on the roof, must have increased greatly the rigidity of the structure. The delicate pyrheliometer bulb did not suffer the slightest damage, and was found to be covered by a singularly small amount of frost. The telephone line from the summit to the base station was also undamaged.

From 12:35 to 1 p.m. April 12, the one-thirtieth mile contact clicks from the anemometer were broadcast from the observatory's ultra-short (5 m) wave transmitter and were received at the Blue Hill Observatory in Milton, Mass., 142 miles south, by Director C. F. Brooks, who timed the contacts by intervals of 5 seconds. Five samplings of one or two minutes each from 12:37 to 12:55 p.m. showed "true" velocities by 5-second intervals ranging from 108 to 216 mi./hr. The fastest 40 contacts, representing a true mile, came in only 17 seconds, or at a rate of 3½ miles a minute (210 mi./hr.). The mean velocities by whole minutes ranged from 148 to 192 mi./hr., and for the 5½ minutes as a unit, a random sampling of this windy hour, 172 mi./hr.

PART II

THE MOUNT WASHINGTON, N.H., HEATED ANEMOMETER

By D. W. MANN

[Mann Instrument Co., 23 Church Street, Cambridge, Mass.]

As briefly mentioned by Dr. C. F. Brooks in the Engineering News Record of May 10, 1934, an experimental heated anemometer which prevented ice deposits was shown him by Dr. Sverre Pettersson, of the Norwegian Weather Service at Bergen, Norway. Using Dr. Brooks' recollection of this instrument as a basis, and working in cooperation chiefly with Mr. S. P. Fergusson and others at the Blue Hill Observatory at Milton, Mass., the writer first constructed an experimental model which, after a preliminary test in the wind tunnel at the Guggenheim Aeronautical Laboratory of the Massachusetts Institute of Technology was put in use for some months on Mount Washington. Later, in October 1933, the anemometer was given further tests at high-wind speeds at the United States Bureau of Standards. This first model was not entirely satisfactory, but the experience gained indicated clearly where improvements were needed in the design to meet the severe conditions to be expected on Mount Washington.

An anemometer was then designed and built embodying the improvements indicated, and with a few minor changes the instrument has since given satisfactory service.

Figure 3 illustrates the anemometer with the front glass removed to show as clearly as possible the electrical mechanism. The main body consists of a bronze casting with a projecting tube above and a base below. This base is fitted with pipe threads to facilitate mounting the instrument on its roof support.

To the base is permanently attached one-half of an electrical junction box, with which both heating and signal circuits are connected. A vertical shaft carrying the rotor passes through the vertical tubular section of the main body and connects the rotor with reduction gearing located in the central section of the case.

Some of the more important features of the internal mechanism are shown in figure 7. Figure 5 is a photograph of the rotor removed from the instrument and inverted to permit inspection of its interior. The rotor made from hard drawn sheet copper spun into a flat pan 6 inches in diameter and 2 inches deep, has a rolled edge to add to its rigidity. The six fins projecting from its outer edge are, practically, shallow cups. The periphery of the rotor is perforated at each cup to permit passage of heated air into the interior of the cup. The diameter of the rotor over the tips of the opposite cups is 8.25 inches and its weight complete without axis is 22 ounces.

To prevent vibration of the rotor an internal bracing web made from spun copper is fastened rigidly to the rotor at its outer edge, and to a brass hub at the center. This hub permits attachment of the rotor to the main shaft by means of a key engaging a keyway in the latter. A screw into the shaft through the top of the rotor holds it firmly in place. This screw does not project above the top of the rotor, because early experiments showed clearly that no projection could be permitted, frost feathers having formed on even a very short thumb screw.

To enclose the heating coils the lower side of the rotor is provided with a spun copper unit having a tubular center, shown in figure 4. In this figure the rotor is removed and the lower part dropped to show the heating coils. To provide for the complete defrosting of the rotor, the air gap between its tubular part and the column is made relatively small, and auxiliary heat is provided at this point. However, this gap is of necessity large enough to prevent the rotor touching the stationary column even under conditions of maximum vibration.

The heating coils consist of Nichrome wires threaded through holes in a series of transite pillars supported by a flat transite disc secured to the main column. Below this transite assembly is the auxiliary heater which consists of a threaded Isolantite tube, upon which is wound the heating coil for defrosting the air gap below the rotor.

The electrical circuits are so connected that the current used in the rotor heating units passes through the auxiliary gap heater and the amount of heat delivered at the gap is somewhat proportional to that used above. Two windings are provided inside the rotor and leads carried through the junction box so either winding may be used alone, or both together as the maximum current required is about 700 watts. To facilitate warming the cups, and in order to prevent overheating of the top bearing, the heating units are concentrated as near as possible to the outer edge of the rotor, and a tube of heat-insulating material is provided to retard the passage of heat from the heater to the bearing in question.

Figure 4 also shows the plug sockets in the junction box; four small ones for the recording circuits, and three larger ones for the heating circuits. Separate leads are used for all electrical circuits, these being entirely insu-

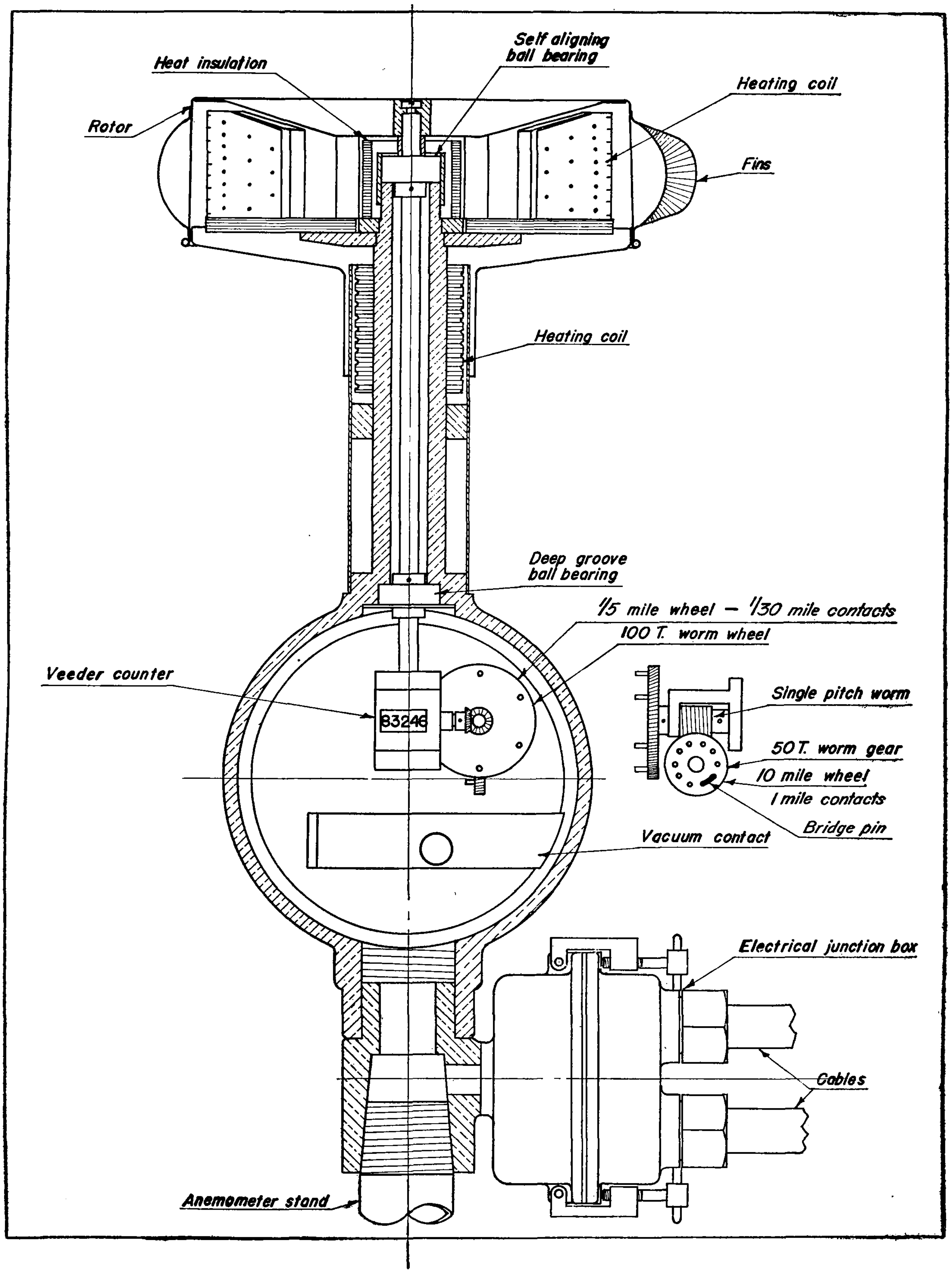

FIGURE 7.—Sectional diagram of anemometer and parts.

lated from the case and from each other. The outer half of the junction box, carrying plugs, is connected by lead-covered cables to the recording apparatus and current supply, and the joint between the two halves sealed with a soft rubber gasket.

The vertical shaft carrying the rotor is provided at the top with an annular ball bearing of the self-alining type, and at the bottom with a deep grove annular ball bearing which also carries the thrust load. A light oil developed by the General Electric Co. for use in watt-hour meters was selected for lubrication. This oil is used because it remains fluid at very low temperatures, as determined by tests by several persons, including the writer, who for a period of several years, worked in cooperation with Mr. B. W. St. Clair of the Lynn works of the General Electric Co., and to whom he is indebted for the oil.

Figure 8 is a schematic diagram, showing the reduction gearing for operating the electrical contacts for recording purposes. A single pitch worm mounted on the lower end of the main vertical shaft engages a 100-tooth worm wheel. Six pins projecting from the face of this wheel operate an electrical contact which gives a signal for each one-thirtieth mile. The shaft on which this 100-tooth wheel is mounted also carries a single-pitch worm which engages a 50-tooth worm wheel on which are mounted 10 pins which give a contact for each mile, 1 mile being recorded for each 500 turns of the rotor. The space between 2 of these 10 pins is made solid to make a long contact for identifying every tenth mile on the record.

Because freezing of the oil film and moisture on the electrical contacts was a source of trouble in the early experiments, a vacuum contact switch, supplied by the Burgess Laboratories, Inc., was selected for the 1-mile recording contact. Since the adoption of this device no trouble whatever has been experienced in their operation under the extreme conditions of temperature encountered.

Uncertainty which the writer felt over a set of anemometer readings made by him during the eclipse of 1932, led to the adoption of a Veeder counter for a visual recorder.

In the early consideration of design it seemed advisable to sacrifice, to some extent, the accuracy at low-wind velocities in order to obtain certainty of operation under the extreme conditions likely to be encountered on Mount Washington. A very recent critical examination of the anemometer, after 14 months of operation, showed no appreciable deterioration.

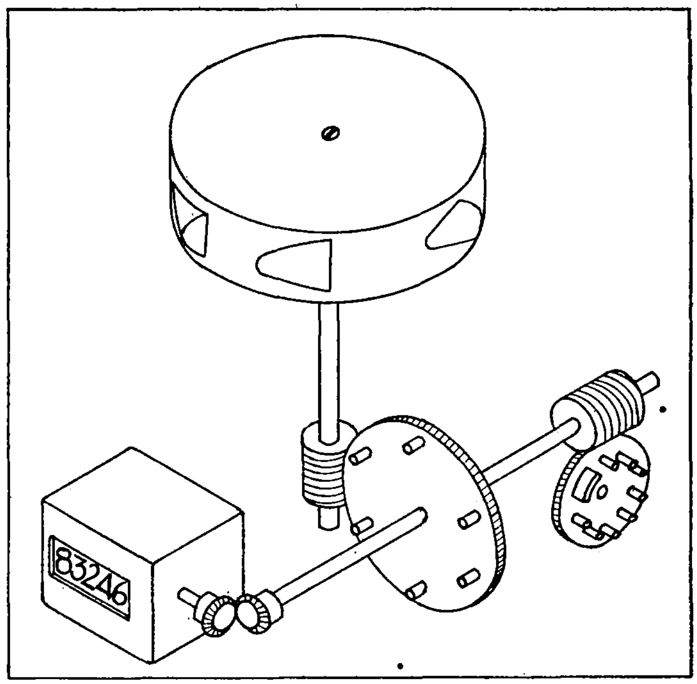

FIGURE 8.—Schematic view of gear system and Veeder counter. In order to indicate tenth of miles the angular motion is stepped down 2 to 1 inside the counter.

The writer takes this opportunity to acknowledge the kind cooperation of the staff of the Mount Washington Observatory in designing the anemometer, and to thank them for their careful handling of it. He wishes also to thank Mr. H. S. Shaw for maintaining a nightly radiotelephone schedule between Mount Washington and his home, and for his help in many other ways in this project.

PART III

THE CALIBRATION OF THE MOUNT WASHINGTON, N.H., HEATED ANEMOMETER AND THE ANALYSIS OF ITS RECORD OF APRIL 11-12, 1934

By CHARLES F. MARVIN

[Weather Bureau, Washington, July 1934]

When Mr. Mann's perfected anemometer (p. 189) was finished and ready for station use it was first sent to the Bureau of Standards to be tested. Two series of tests of its performance were made during November 1933. One run under a turbulence of about 0.5 percent, comprising a range of velocities from 11.6 miles per hour, just above the starting speed of the rotor, to 143.4 miles per hour, was made in the small 36-inch wind tunnel; the other, under about the same small turbulence, was made in the 54-inch wind tunnel. In view of the relatively small size and compact form of the rotor little or no blocking or other effect depending on the size of the tunnel could be expected, and the agreement between these tests was very close and highly satisfactory.

The calibration-curve representing these tests in the form shown in figure 9–A, as furnished by the United States Bureau of Standards, has been used by the Mount Washington Observatory for the reduction of all the station records.

After the great April 1934 storm and the reading of Mr. Pagliuca's paper on it at the April 1934 meeting of the American Meteorological Society, comments at the Weather Bureau and elsewhere on the accuracy of the reduction of the record led Dr. C. F. Brooks, Director of the Blue Hill Observatory, to send Mr. Pagliuca to Washington in June with the instrument for new tests. The primary object of these tests was to ascertain: (1) Any change since the previous tests in the ordinary performance of the instrument; (2) effects of inclining the axis forward or backward from the vertical; and (3) whether the run of the rotor was much or little affected by turbulence in the test wind stream.

The results of these tests may be stated briefly, in order, as follows:

(1) *Ordinary performance.*—Although neither change by use and exposure nor any alterations or injury that could affect the run of the rotor has been known to occur since the first test, nevertheless the second tests in both